

Predictability of climate tipping : data assimilation approach

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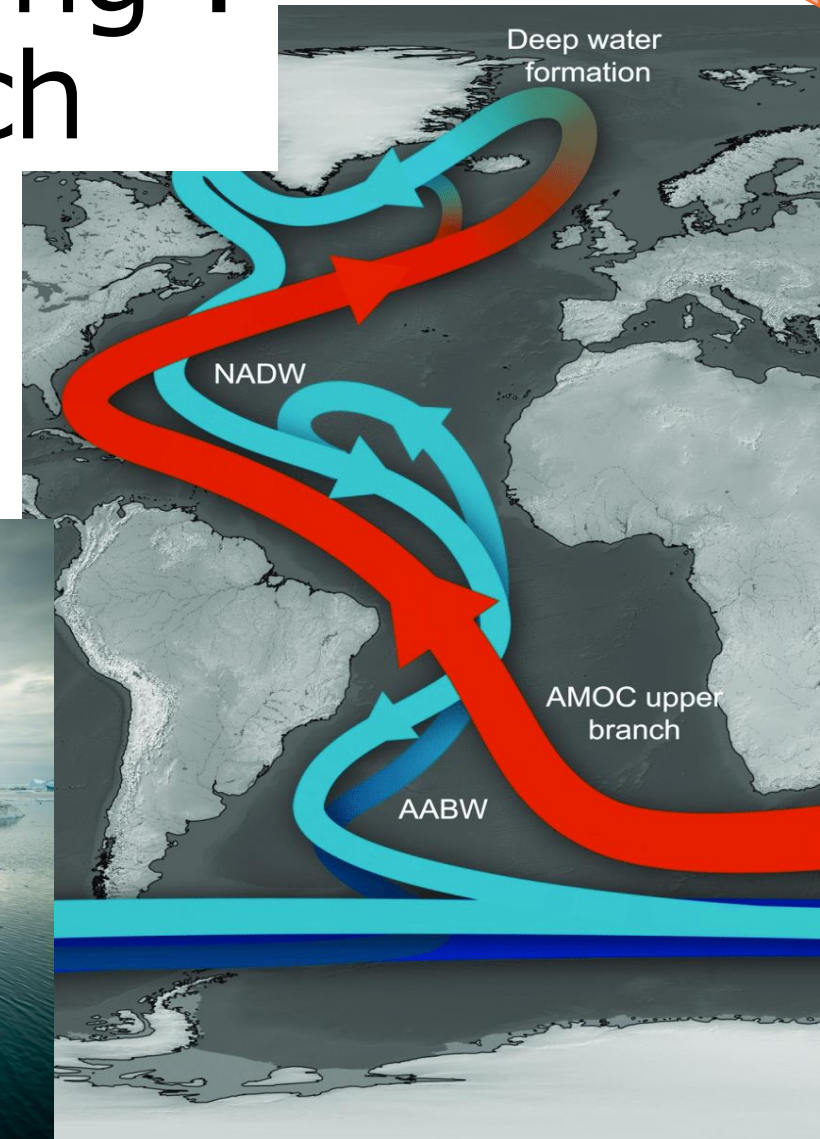
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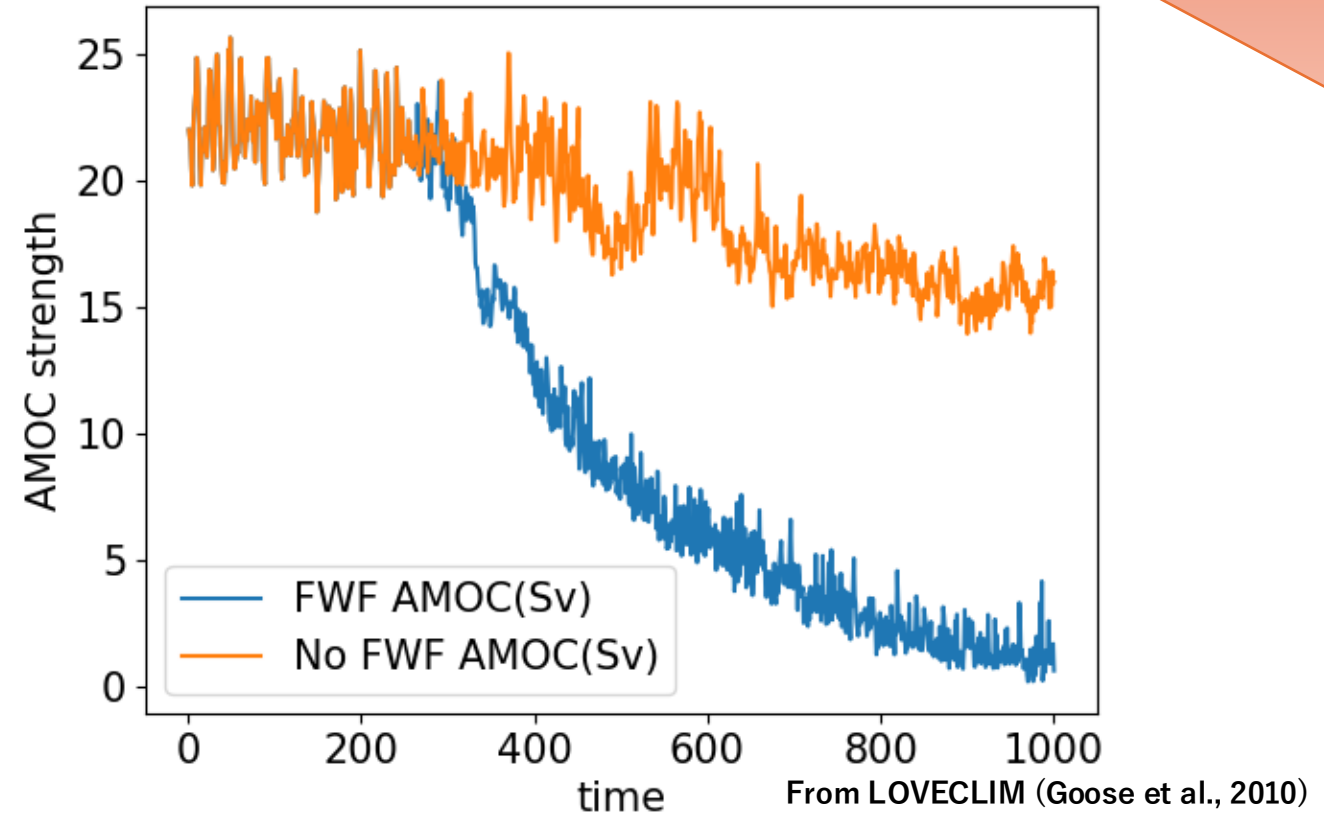
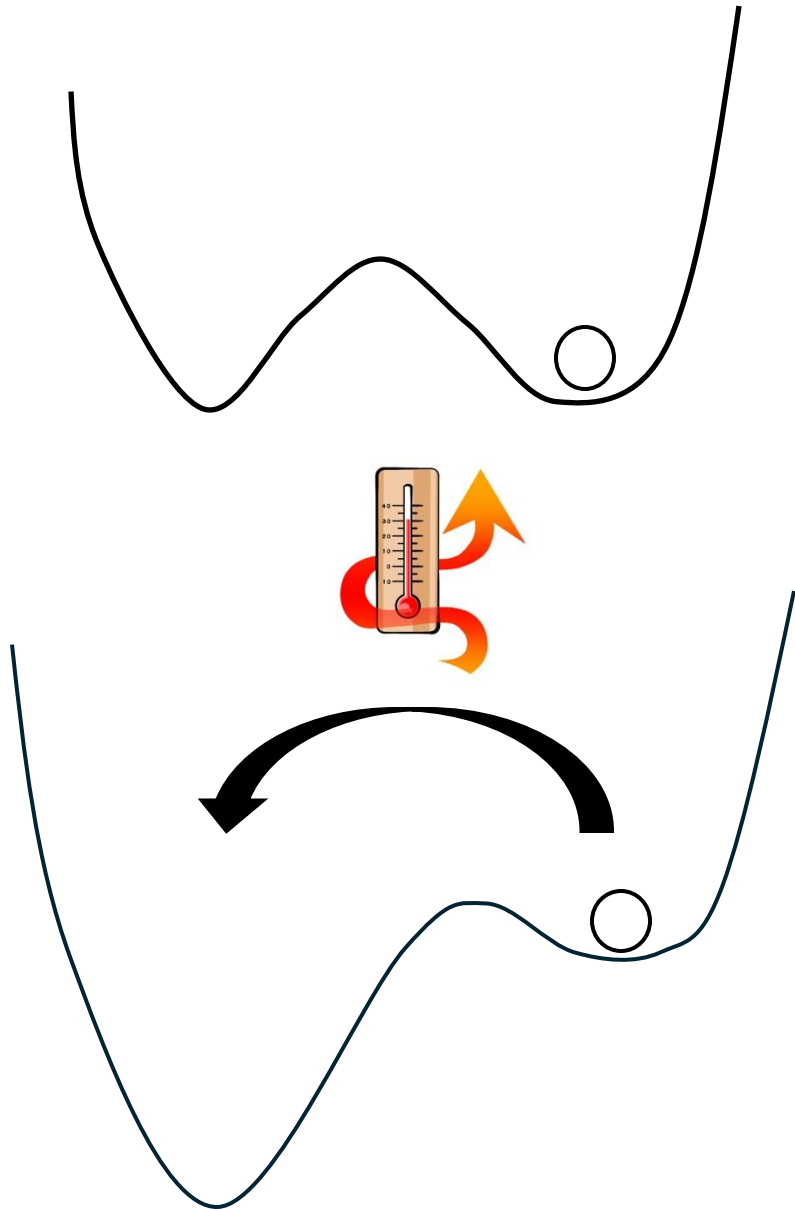


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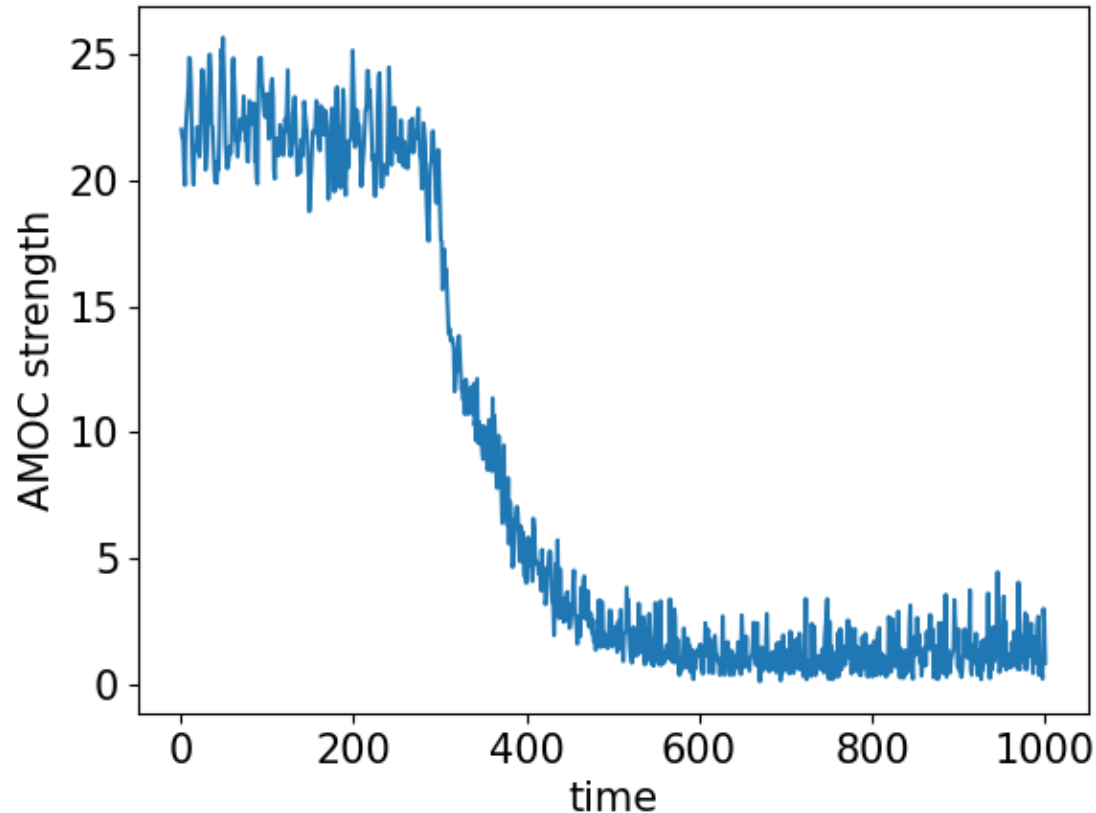
Climate tipping



- ❑ Transition from one long-term stable state to another state
 - ❑ Irreversible and have huge impact
- Prediction of climate tipping is important

Climate tipping & data assimilation

Climate tipping includes lots of interesting topic related to data assimilation



From LOVECLIM (Goose et al., 2010)

➤ Predictability

- Application of the framework of weather predictability

➤ Nonlinear Data assimilation

- DA robust to strong nonlinear system is necessary

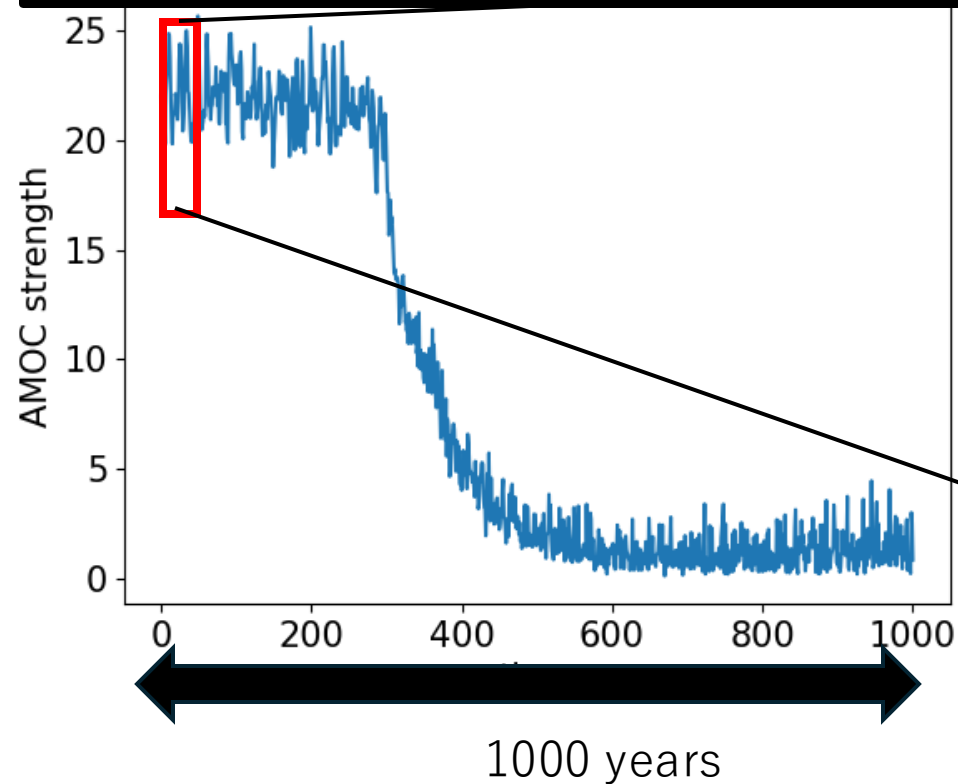
➤ Efficient Data assimilation

- Efficient enough to cope with high-dimension system

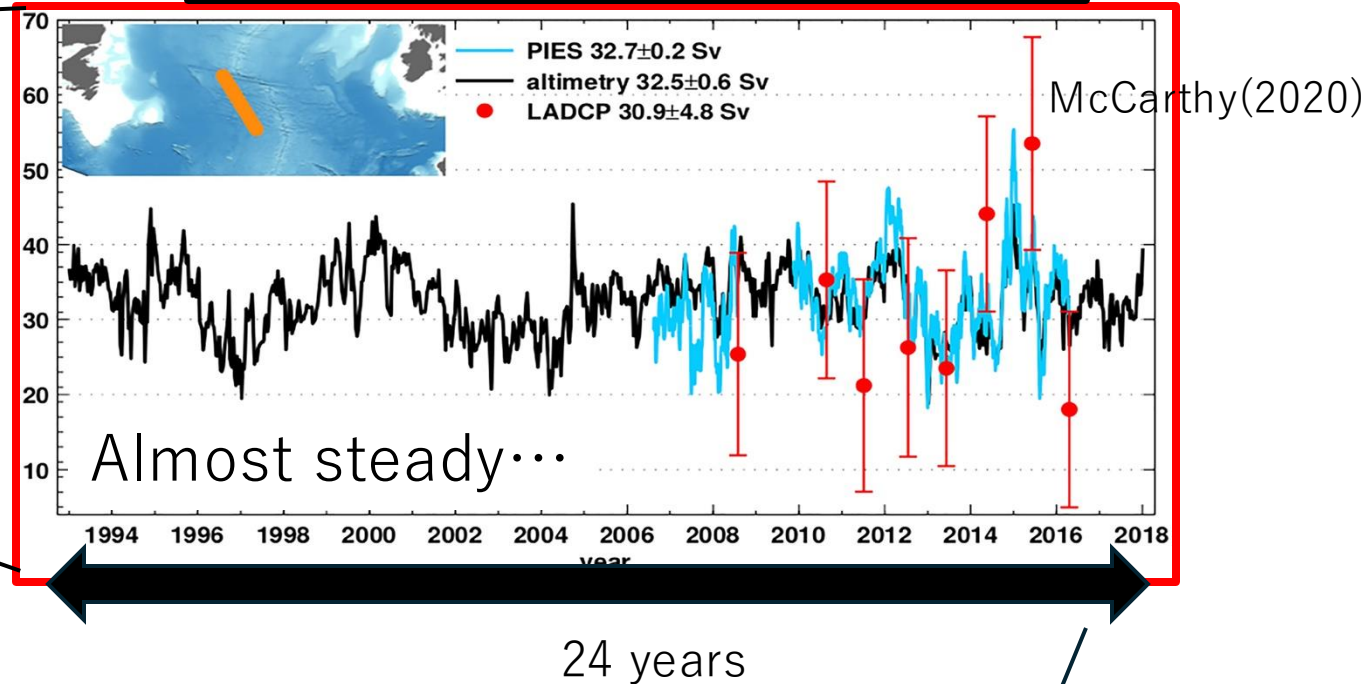
This study is the first step to assess the practical predictability of climate tipping

Feature of climate tipping observation

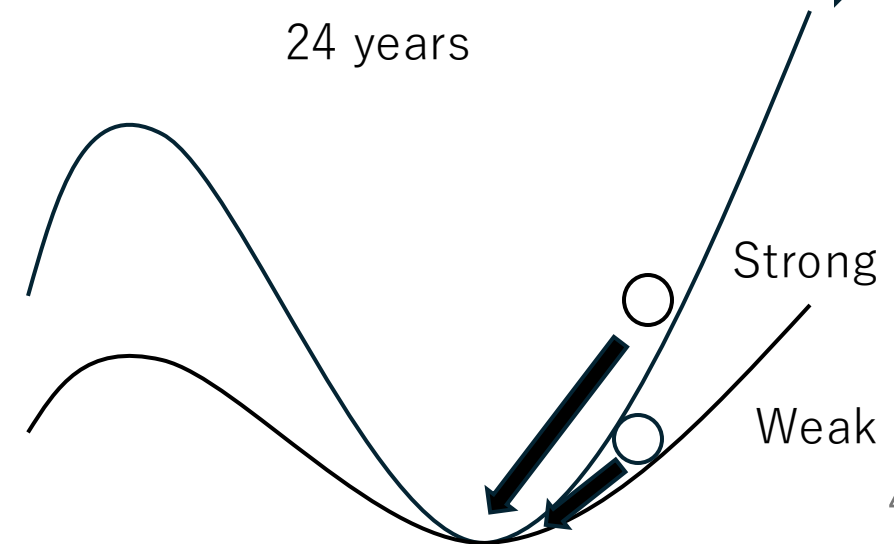
Model simulation of AMOC



Observation of AMOC



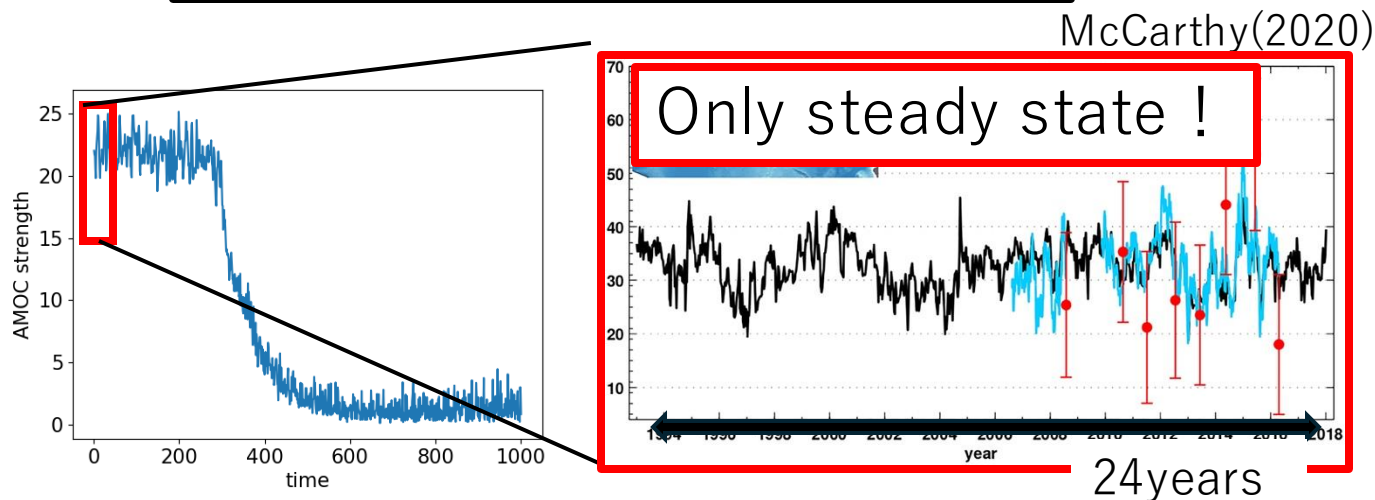
Stability of the system can be inferred from internal variability. Scheffer(2009)



Research question

- Is the observation **without climate tipping** possible to improve model prediction of **whether or not and when climate tipping will happen?**

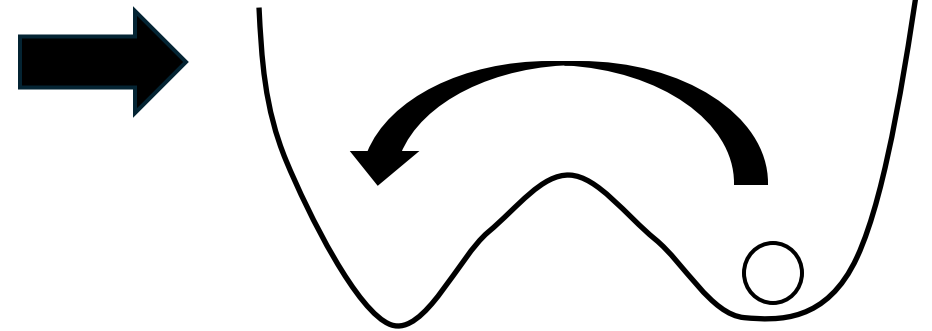
Observation deficit



Sam Sherriff-Tadano et al.(2021)

2500years

Can predict tipping?

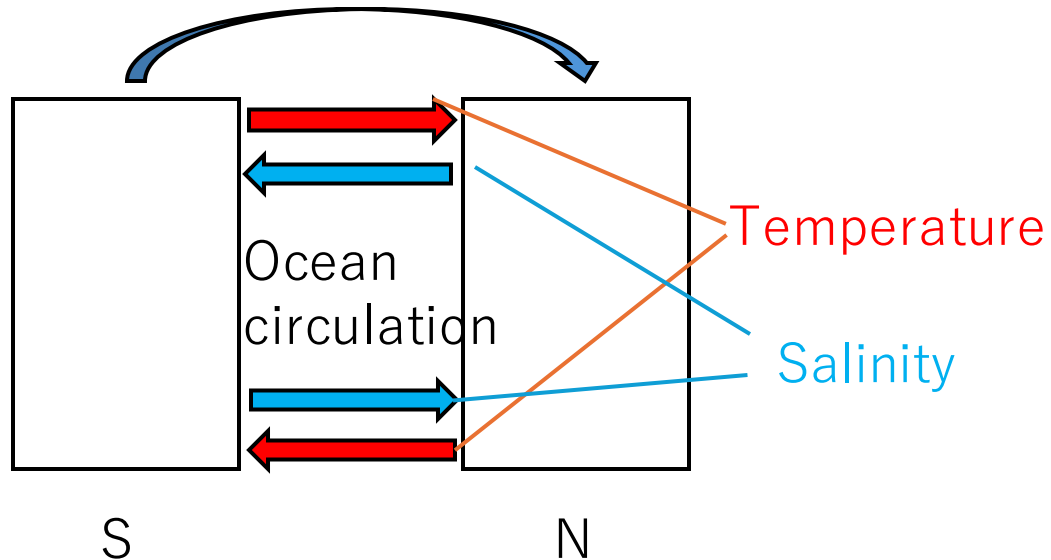


Climate tipping model and scenario

Temperature scenario

AMOC two-box model

Freshwater flux

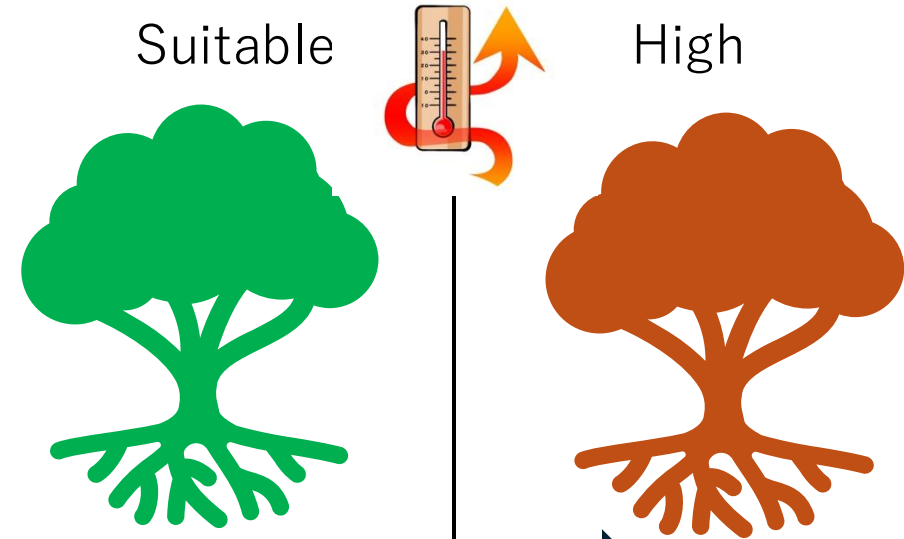


AMOC strength

Amazon forest model

Suitable

High



Tropical forest ratio

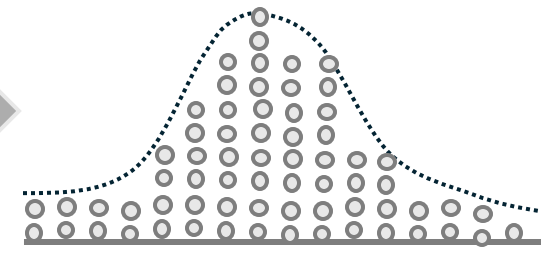
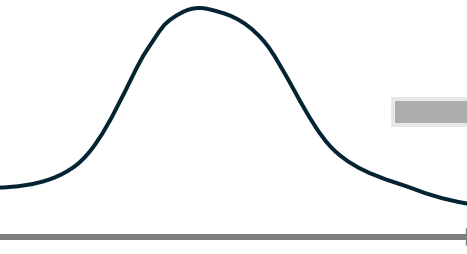
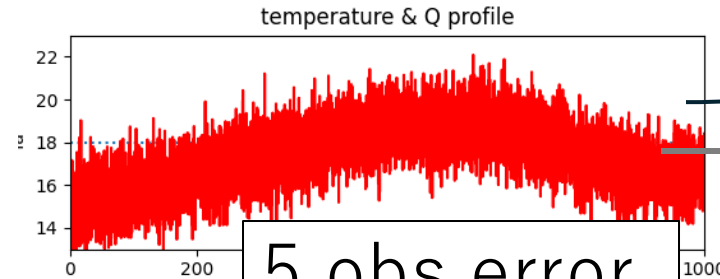
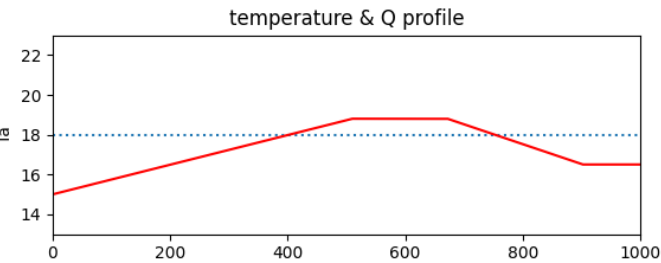
Detailed setting of OSSE

Forcing variability setting

Temperature timeseries

Particle filter

1000 members



True model

True state

5 Forcing variability

5 obs error
6 obs freq

3 obs error
6 obs lead time

Compare

Observation

Model

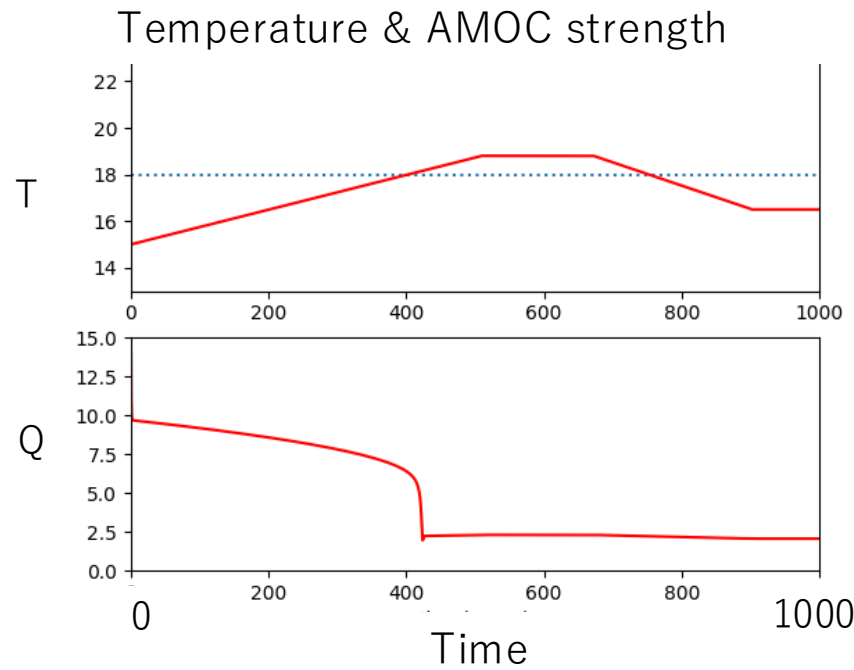
Model output

Only 2 parameters are unknown

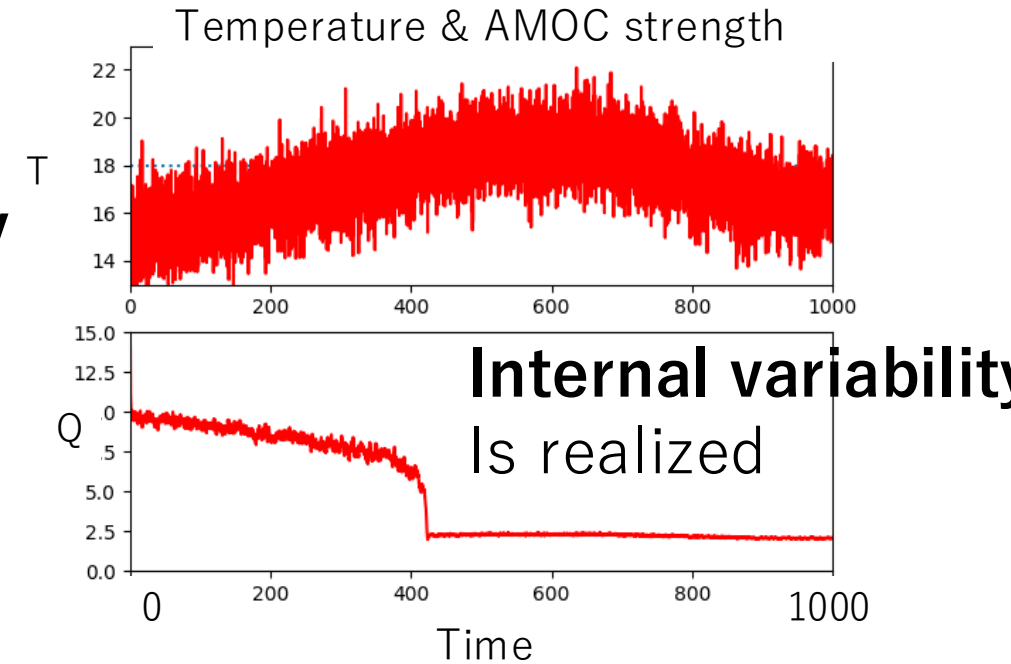
100 trials on each observation and model setting

What is the expected effect of the internal variability?

Expectation



Adding
Forcing variability



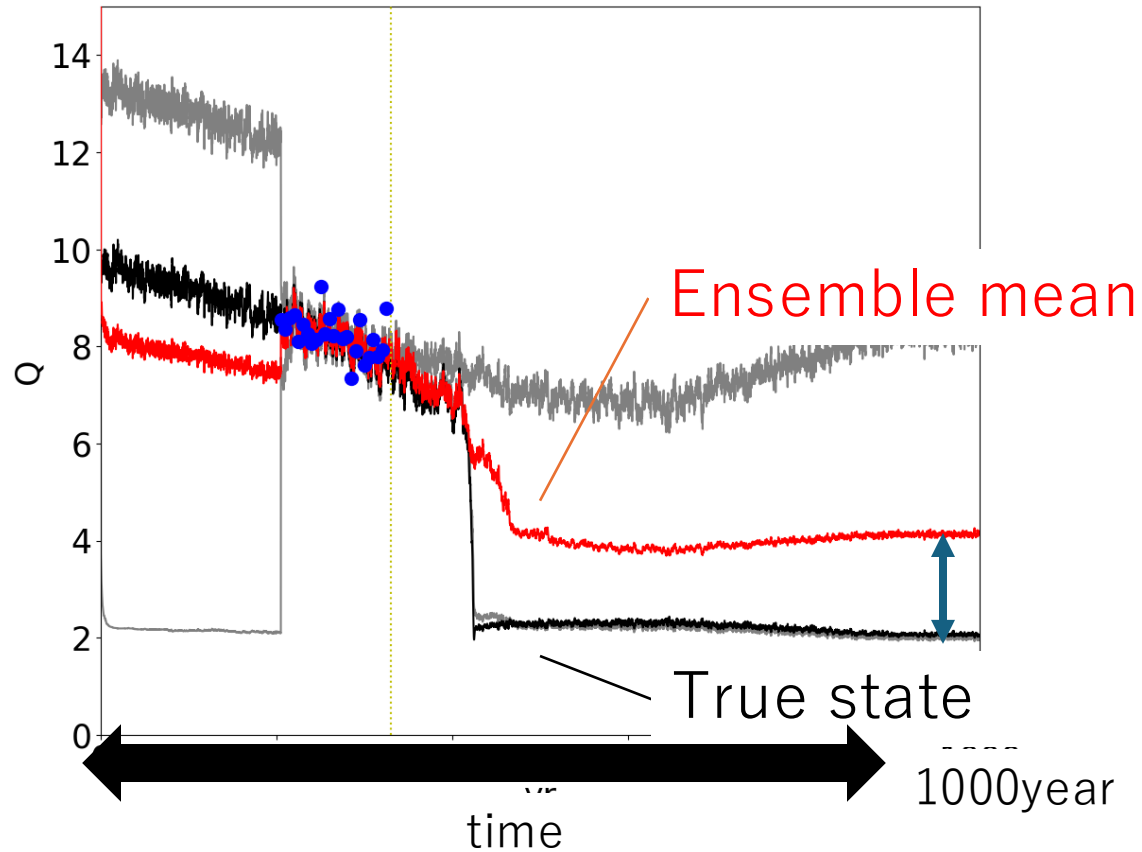
Forcing variability is noise and prediction of such random change is difficult

Potential to increase the predictability because we can see the response which is not observed w/o forcing variability.

Data assimilation improves the model prediction

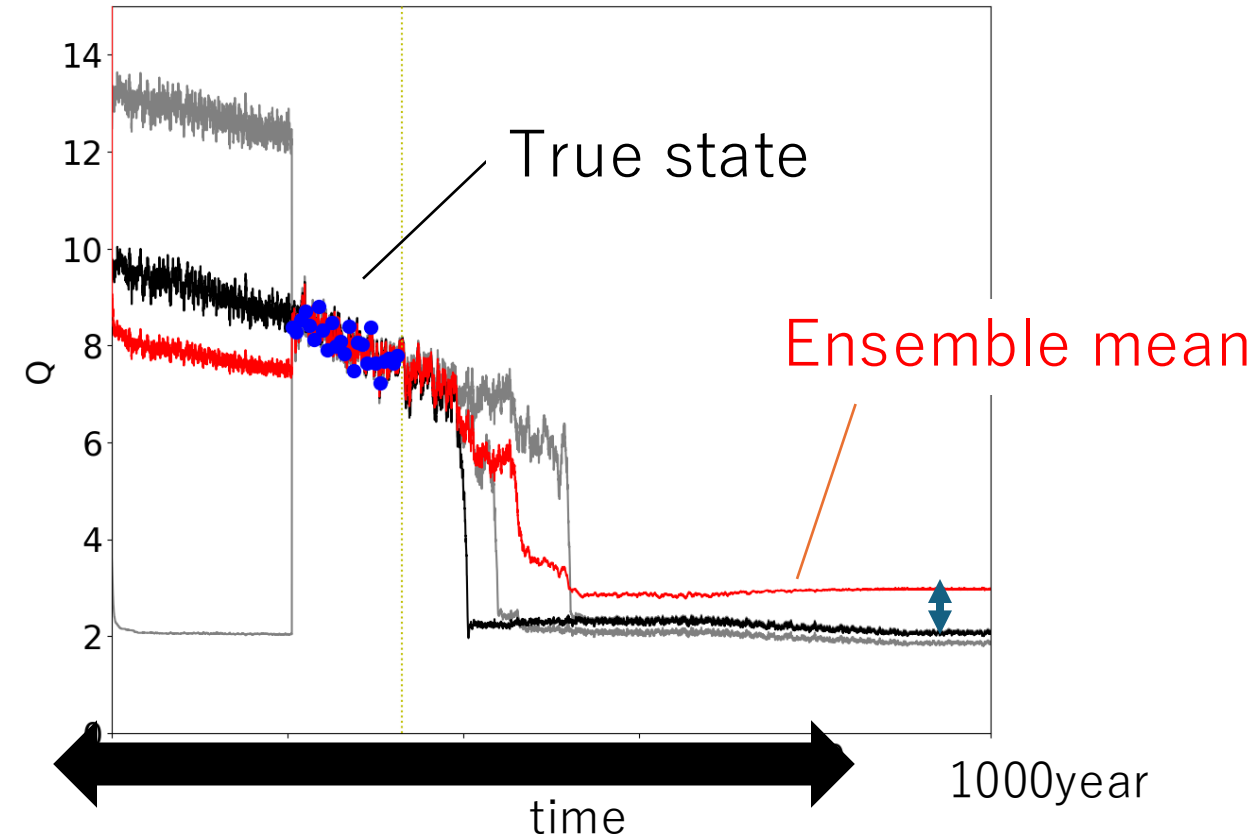
● Observation

Inaccurate observation



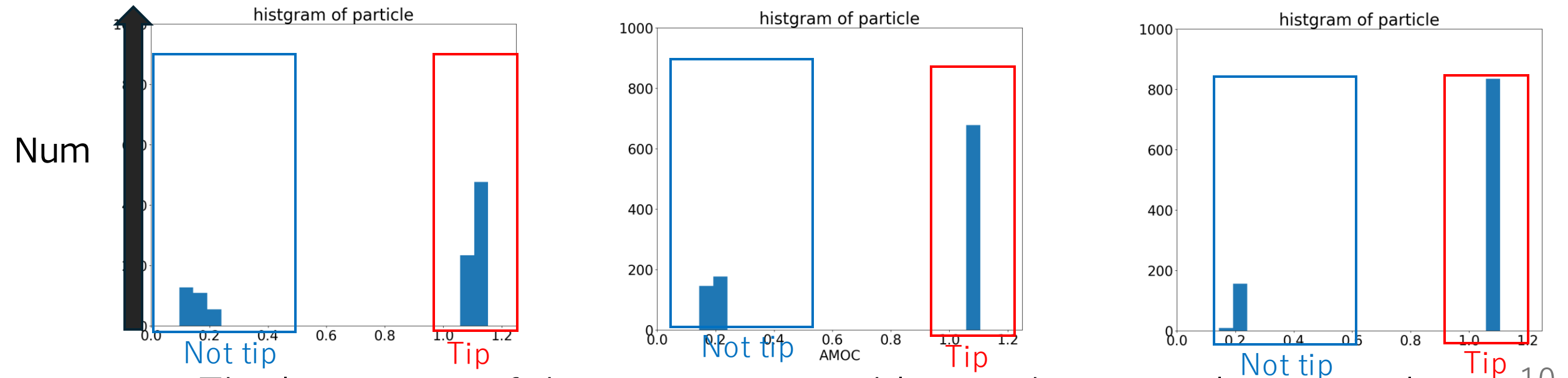
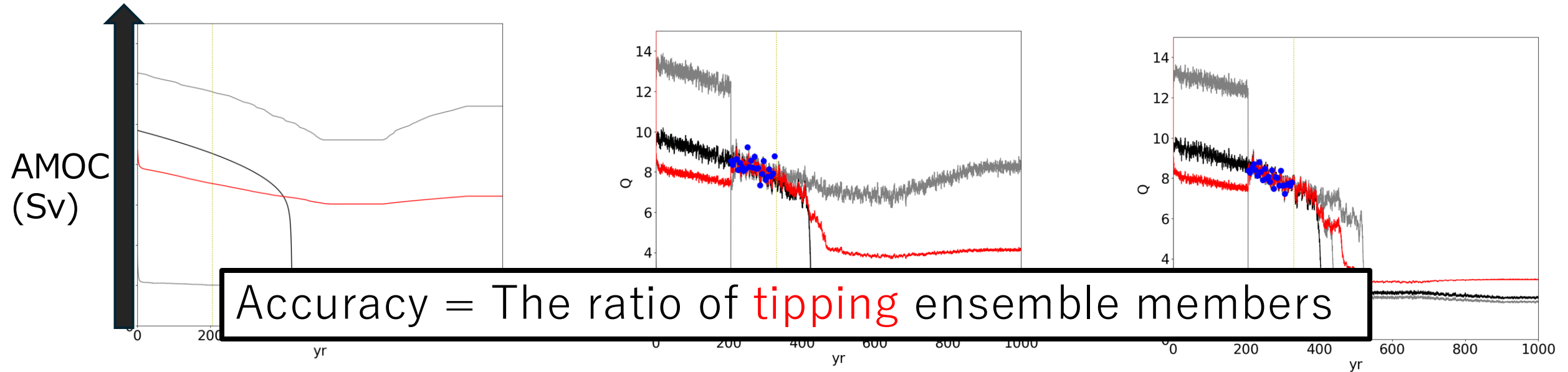
Not accurately predict tipping

Accurate observation



Accurately predict tipping

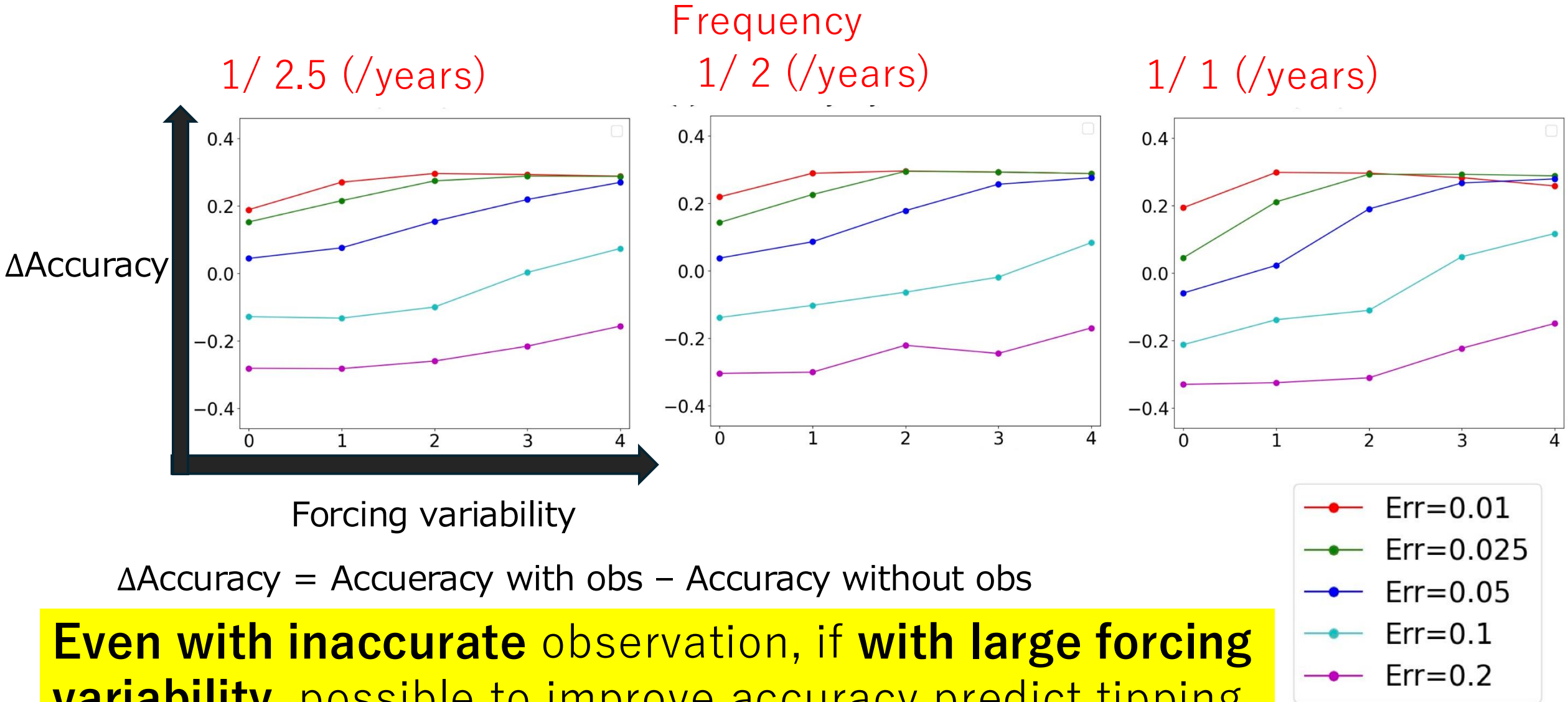
Metric of prediction accuracy



The last states of the tipping ensemble members are always similar. 10

Less accurate obs is effective with large forcing variability

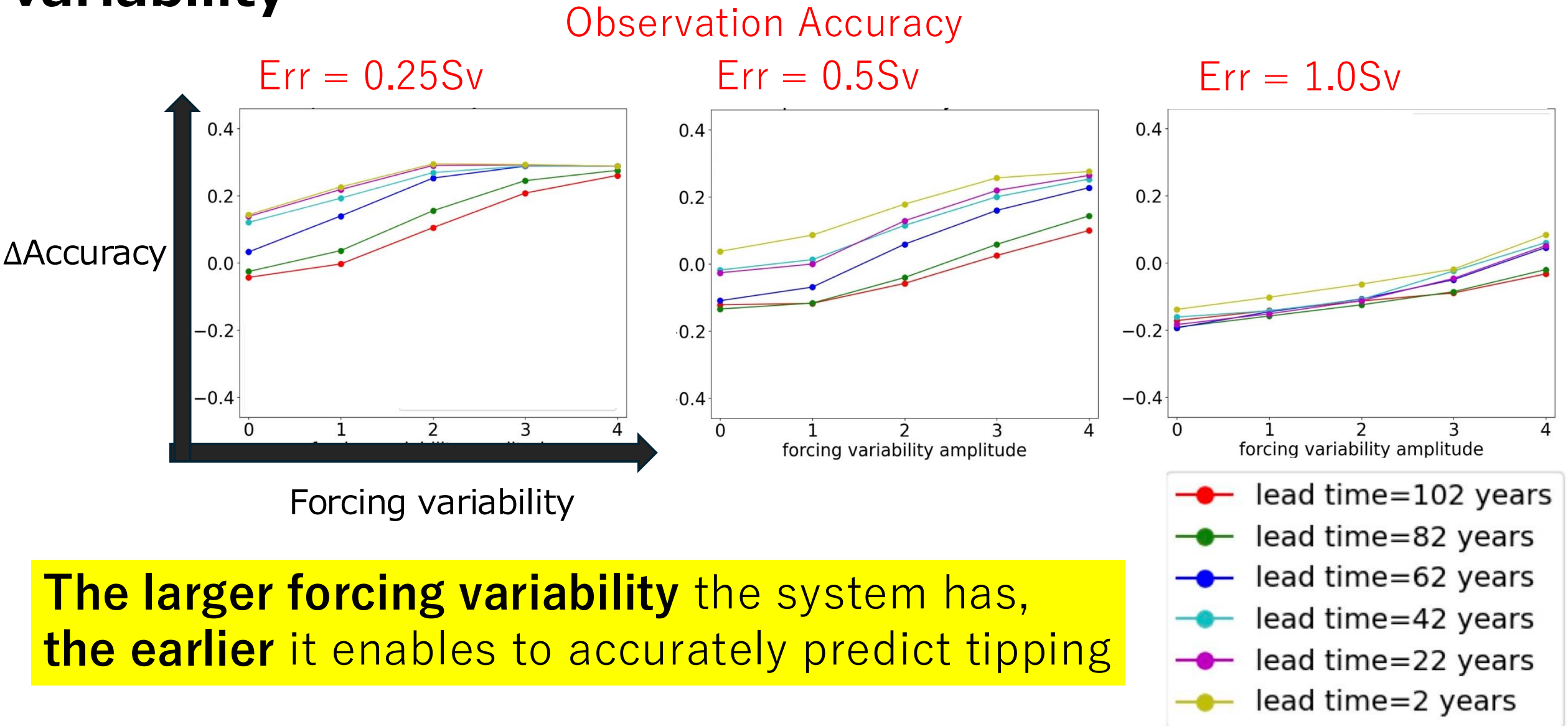
Result



Even with inaccurate observation, if with large forcing variability, possible to improve accuracy predict tipping.

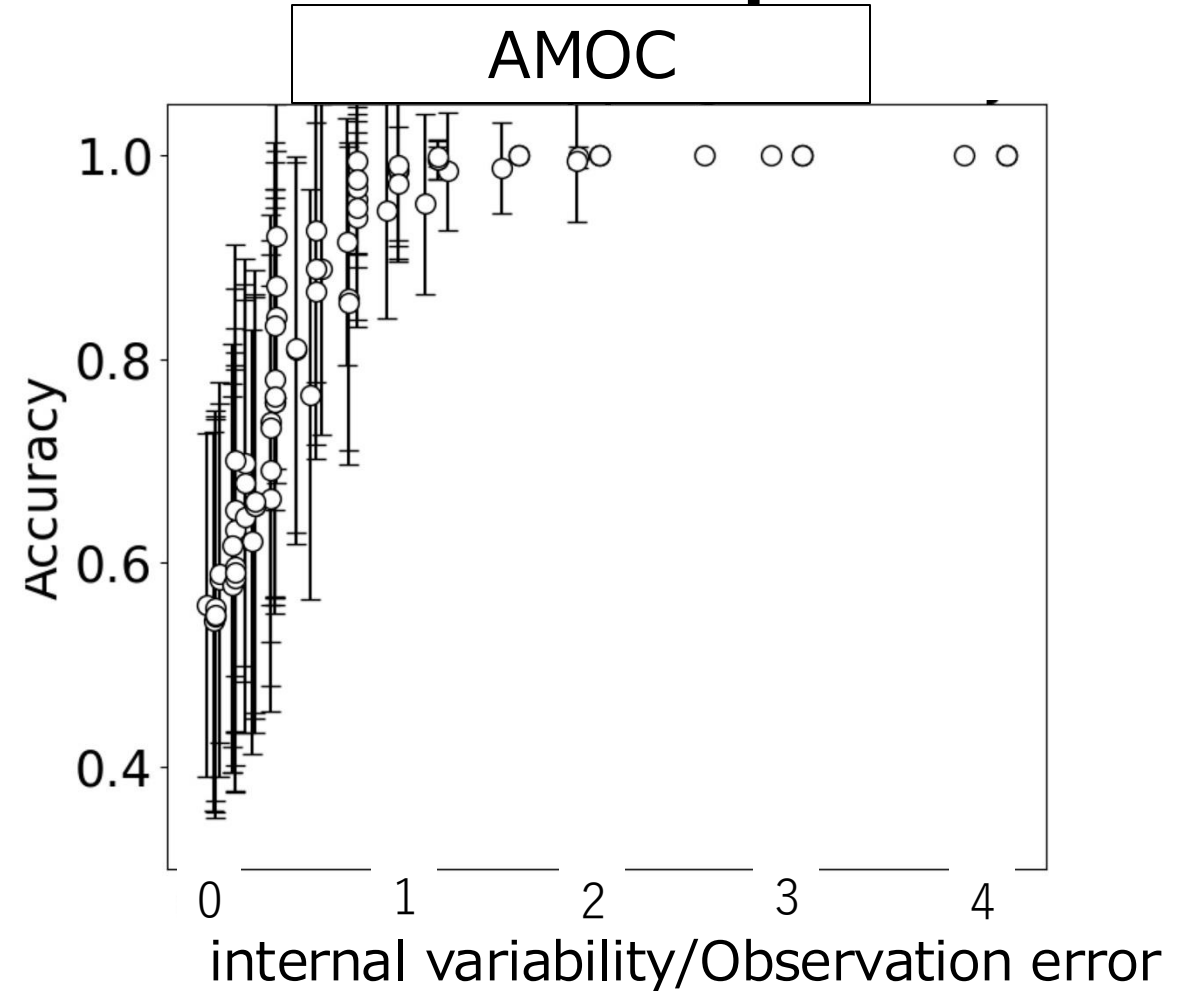
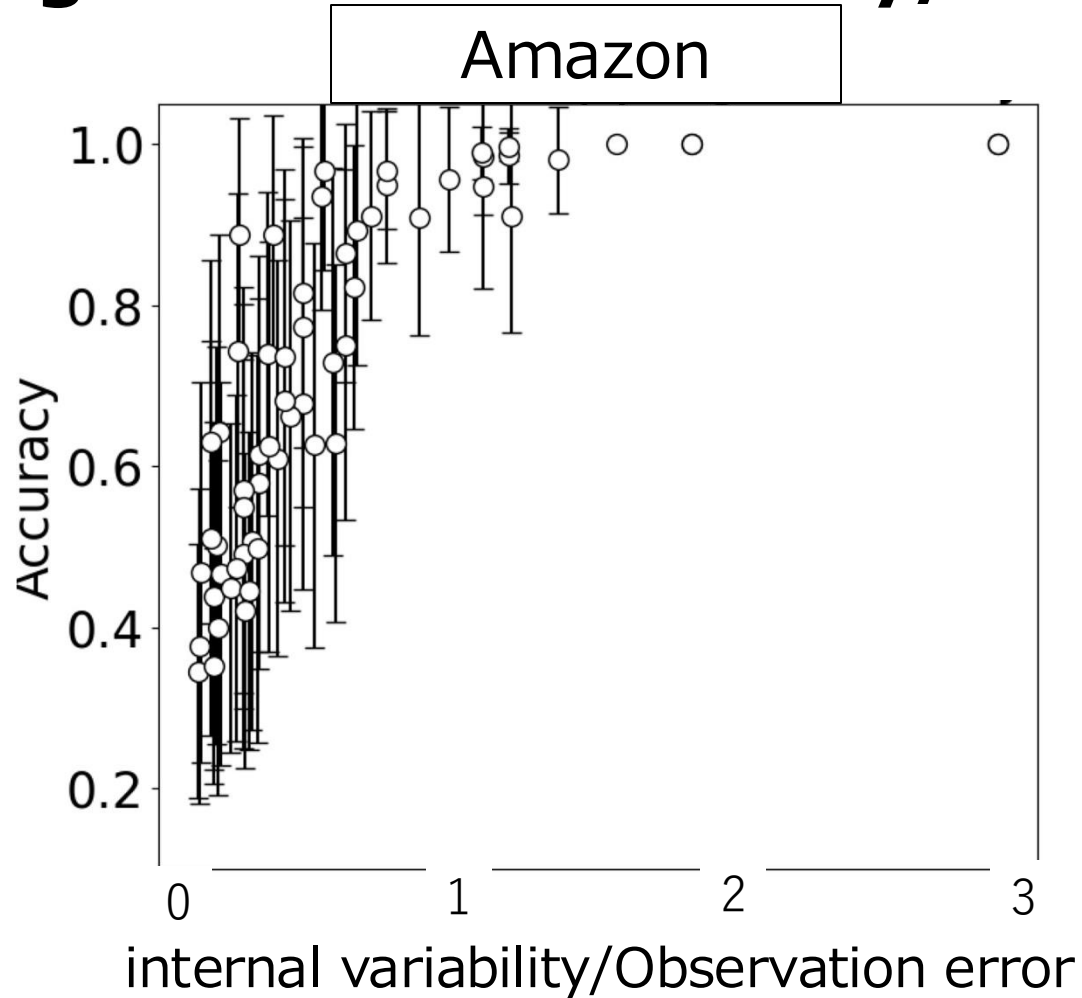
Longer lead time is realized with larger internal variability

Result



High internal variability/Observation error is important

Result



The higher internal variability/Observation error is, the **more accurate** prediction of climate tipping is realized

Summary

- We first discuss the predictability of Climate tipping
- **Direct observation** of climate tipping is **not always necessary** if you have accurate model to describe climate tipping
- Observation which **resolves internal variability** is important
- Of course there is huge limitation of this study because we use just two simple conceptual models with finite settings.

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